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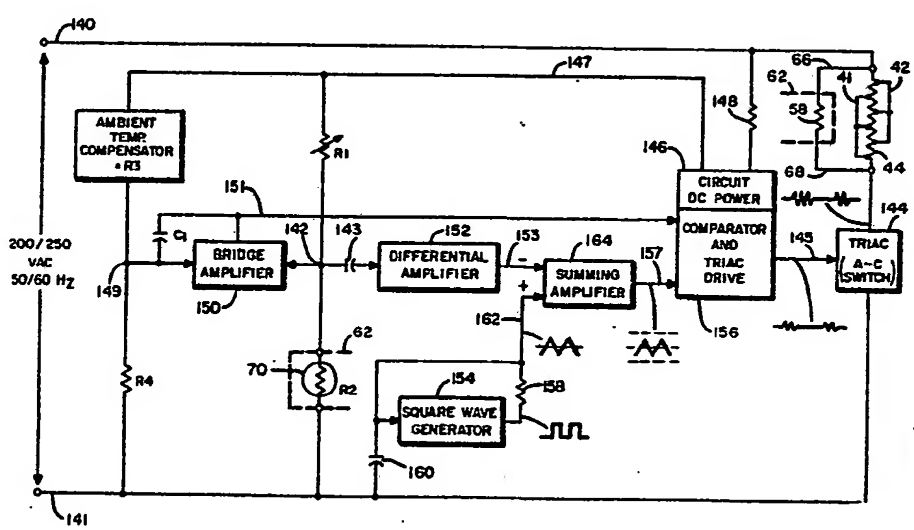
(54) Title: TEMPERATURE CONTROL SYSTEM FOR ELECTRICALLY HEATED HOSE UTILIZING HOSE SIMULATOR TEMPERATURE DETECTION

(57) Abstract

In coating systems wherein multiple coating components are separately applied by a hose to the point of application and are mixed and applied by a common applicator gun to a surface, e.g., the application of a urethane foam coating to a building roof, the quality of the applied coating is dependent upon the temperature of the coating components as well as the temperature of the surface to be coated, the latter temperature being proportional to the ambient temperature in the vicinity of the point of application. To insure optimum coating quality, the invention incorporates into the hose (16) a heating tape (40) having a resistance heating element (44) closely controlled by an electronic temperature control circuit (18) responsive to both an ambient temperature sensor (22) comprising temperature sensitive resistance (R3) and a hose simulator (60) separated from the hose (16) and having heat loss and absorption characteristics similar to the hose (16) and including a temperature sensing element (70) potted together with a resistor (58) in a mass of epoxy compound (59) to form a module (62) wrapped in an insulation blanket (64). The resistor (58) and sensing element (70) are spaced apart a predetermined distance selected to provide a degree of heat correlation comparable to the rate at which the hose (16) accepts heat from the heating tape (40) so that the temperature of the simulator (60) tracks the temperature of the hose (16) nearly identically.



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TEMPERATURE CONTROL SYSTEM FOR ELECTRICALLY HEATED HOSE UTILIZING HOSE SIMULATOR TEMPERATURE DETECTION

Background of the Invention

The present invention relates to a system for heating fluid hose, and more particularly to a system for heating fluid hose in applications wherein one or more fluid components are delivered through the hose from a remote location to a point of application.

The invention is particularly adaptable for systems requiring close temperature control over liquid components such as multiple component coatings which are separately delivered to a point of application, and are mixed and applied from a common applicator or spray gun. Systems of this type generally require fairly precise control over the temperature of the delivered fluid, and the quality of coating application is dependent upon both the temperature of the liquid components and the temperature of the surface to which the components are mixed and applied. Such systems may be found in industrial plant installations, wherein the liquid temperature at the point of application is at least somewhat controllable by monitoring the industrial plant ambient temperature. However, such systems are also useful for coating applications in an outdoors environment. For example, such systems are utilized in the application of plural component urethane and other foam materials for the application of roof coatings on buildings. In this latter case, the coating application problem becomes complicated in a number of important

respects. First, the components typically applied in such applications are generally quite temperature responsive and sensitive, and for optimum coating quality these temperatures should be closely controlled. Further, the quality of coating is significantly affected by the temperature of the surface which receives the coating, and in the case of building roofs may be higher than, but proportional to the ambient air temperature. Still further, the nature of a practical roof coating application requires that hose lengths extend for considerable distances, and be very ruggedly constructed because of the physical abuse the equipment suffers in hauling it to the point of application. At the same time, the liquid materials flowing through the hoses must be kept at a constant temperature, within a fairly narrow range, in order to insure that the temperature of the liquid at the point of mixing and application of the fluids be reasonably well-defined. Because of the physical abuse that the hoses tend to take over use, it is very difficult to construct an intricate temperature sensing mechanism into the hose itself. Further, because of the widely ranging requirements for conveying the liquids over greater or shorter distances, it is convenient to provide such hose in sections, in convenient lengths of twenty-five or fifty feet. Thus, hose couplers must be provided at both ends of each extension length, capable of connecting all of the liquid, air, and electrical circuits together reliably. If hose extension lengths must also carry temperature sensing circuits, electrical connections for these circuits must also be provided and such circuits must be ruggedly packaged in each extension length of hose.

There is a need for a system for delivering heated liquid through extended hose lengths, wherein the hose

is heated to carefully control the temperature of the liquid being delivered, and wherein the temperature control and monitoring system may be safely contained to reliably operate under adverse environmental conditions. Further, there is a need for a heated hose temperature control system which takes into account the ambient temperature conditions at or near the point of application in adjusting the liquid temperature being delivered to the point of application. It is a principal object of the present invention to provide a system meeting these needs to enable liquid coatings to be applied under optimum application conditions.

Summary of the Invention

The present invention includes a system for electrically heating a fluid hose, wherein the hose may carry one or more components and a supply of pressurized air, all to a point of application, preferably through a spray gun. The system further includes a temperature monitor for detecting the ambient temperature in the vicinity of the point of application, and further includes a hose simulator having heat transfer characteristics matching the heat transfer characteristics of the delivery hose, wherein the heat transfer of the simulator may be utilized to control an electrical heating circuit for the delivery hose. The electrical heating circuit may be adjusted to deliver electrical energy to the heated hose and to the hose simulator in response to the heat transfer characteristics of the hose simulator, and in further response to the ambient temperature in the vicinity of the point of application.

Brief Description of the Drawings

The invention and its operation are described herein, and with reference to the appended drawings, in which;

FIG. 1 shows an illustrative view of the invention in a typical construction; and

FIG. 2A shows an isometric view, in partial cutaway, of a typical hose construction; and

FIG. 2B shows an isometric view, in partial cutaway, of the heating element construction; and

FIG. 2C shows an electrical schematic of the hose heater; and

FIG. 3 shows a cross section view of a hose simulator; and

FIG. 4A shows a cross section view of a control module; and

FIG. 4B shows a view taken along the lines 4B - 4B of FIG. 4A; and

FIG. 5 shows a schematic block diagram of the temperature control circuit.

Description of the Preferred Embodiment

Referring first to FIG. 1, there is shown an illustrative view of a typical application wherein the invention is used to advantage. A vehicle 10 is equipped to transport the invention and related equipment to a work site. In a typical application, the equipment might be used to apply a mixed, two-component foam material to a roof surface 12. The material is applied via a spray gun 14 which receives heated liquid components through a hose 16. Hose 16 receives its liquid components from a pumping system 20, which is typically mounted on vehicle 10. Pumping system 20 includes a temperature control 18 which houses a hose simulator, and an ambient temperature monitor 22 which is located so as to monitor the temperature in the vicinity of the point of application.

FIG. 2A shows a cutaway view of a section of one form of hose 16. An outer covering 24 serves to protect the hose and other inner components from damage caused

by physical abuse. An insulation layer 26, preferably constructed from resilient plastic or rubber foam material, serves as an insulation blanket to provide temperature insulation for the components it encloses. One or more liquid component hoses 28 and 30 are contained inside of insulation layer 26, the hoses themselves being constructed of multiple layers of material for efficient operation. For example, hose 30 includes an outer covering 32, one or more braided layers 34 for strength and protection, and an inner tube 36 for conveying an application liquid. An air hose 38 is also contained within insulation layer 26. Air hose 38 delivers pressurized air to spray gun 14 to assist in the atomization of the liquid components in the spraying process. A heating tape 40 is contained within insulation layer 26, to generate the necessary heat energy for the operation of the invention. Heating tape 40 includes a pair of buss wires 41 and 42 for conducting the electrical energy in a manner to be hereinafter described. Heating tape 40 is preferably formed with an electrically grounded outer shield which will be described hereafter in more detail.

FIG. 2B shows an expanded and partial cutaway view of a type of heating tape 40. Heating tape 40 has an outer cover 43, which may include a grounded braid with an insulating layer. A heating element 44, preferably made from Nichrome wire is coiled about an insulating sheet 45. Heating element 44 extends throughout the length of heating tape 40. Heating element 44 is periodically electrically connected to buss wire 41 and 42, with alternate connections being made to these buss wires along predetermined lengths A of heating tape 40. These alternating connections are preferably made at about 24 inch intervals along heating tape 40.

FIG. 2C shows an electrical schematic of the connection between buss wires 41 and 42, and heating

element 44. For example, heating element 44 is connected to buss wire 41 at point 46, and is next connected to buss wire 42 at point 48, which is a predetermined distance A along heating tape 40 from point 46. In this manner, a plurality of parallel electrical connections are constructed between heating element 44 and buss wires 41 and 42. When a voltage source 50 is connected across buss wires 41 and 42, a plurality of parallel current paths are provided between the buss wires and through respective sections of heating element 44. In another form of heated hose construction the heating wires may simply be constructed as a parallel or twisted pair of buss wires running the entire length of the hose section, with one or more heating wires also running the entire length of the hose section, where one buss wire is electrically connected to a heating wire at one end of the hose section and the other buss wire is electrically connected to the heating wire at the other end of the hose section. In this case the schematic representation of FIG. 2C indicates a length A corresponding to the length of a single hose section. Naturally, the type and size of heating wire selected for use in the heated hose is a function of the particular application design chosen.

FIG. 3 shows a side view in partial cross section of hose simulator 60. Hose simulator 60 includes an inner control module 62, which is wrapped in an insulation blanket 64. Insulation blanket 64 is preferably constructed of resilient foam material. The thickness of insulation blanket 64 is selected to provide the same or similar insulation characteristics as does the insulation covering of a section of hose. The overall objective of hose simulator 60 is to provide heat transfer characteristics which are matched to a section of heated hose 16. Insulation blanket 64 is closed

about control module 62 at each of its ends, thereby forming a closed insulation compartment for control module 62.

FIG. 4A shows a cross section view of control module 62. A resistor 58 is potted into an epoxy compound 59, having each of its electrical connections respectively connected to wires 66 and 68 which extend external to the potted epoxy compound. Further, a temperature sensing element 70 is also rigidly held within the potting compound 59, having two electrical wires 72 and 74 extending external to the potted epoxy compound. Temperature sensor 70 is spaced away from resistor 58 by a predetermined distance, the distance being selected to provide a degree of heat correlation comparable to the rate at which the liquid hoses in the heated hose accept heat from the heating tape which is also within the heated hose. FIG. 4B shows a view taken along line 4 - 4 of FIG. 4A. Resistor 58 is proximately centered in potting compound 59, so as to equalize the temperature dissipation from resistor 58 through potting compound 59 when the resistor is energized electrically. It has been found preferable to utilize a resistor 58 valued at 20,000 ohms, having an 11 watt power capacity. In practice, the physical size of control module 62 has been found to match the heat transfer characteristics of hose 16 when control module 62 is approximately 1 1/2 inches (3.75 cm) wide, 2 1/2 inches (6.25 cm) high, and 1/2 - 3/4 inch (1.25 - 1.9 cm) thick. Specific departures from these dimensions may be made to accommodate particular hose types, and of course are a function of the hose insulation, heating tape, and other variables, including the type and nature of the liquid fed through the hose.

FIG. 5 shows a schematic block diagram of the temperature control circuit 18, and its connections to heating element 44 and resistor 58. Alternating current

voltage is applied at power lines 140 and 141. This alternating current voltage may typically be 200/250 volts AC, at 50/60 hertz(Hz). AC power line 140 is wired to buss wire 42 which connects to heating element 44. Resistor 58 is electrically connected in parallel to the connections to heating element 44, so that when electrical power is applied to heating element 44 it is also applied to resistor 58. AC power line 141 is connected to triac circuit 144. Triac circuit 144 is an AC power switch, of a type well-known in the art. In the preferred embodiment triac 144 is manufactured by Raytheon Company, under type designation TAG 741. Triac circuit 144 has a control input line 145, the voltage signals appearing on input line 145 causing triac circuit 144 to turn "on" and "off" as a function of these input signals. AC power line 141 also serves as a circuit common or ground connection. Triac 144 is also connected to buss wire 41, to complete the electrical power connections to heating element 44.

Direct current power to operate the circuit shown on FIG. 5 is obtained through a circuit DC power supply 146, which receives its input power through dropping resistor 148, and a connection to circuit ground (not shown). DC power supply 146 provides a DC voltage in line 147 and other lines not shown, for operation of the circuits to be hereinafter described.

A resistance bridge circuit is formed by resistors R_1, R_2, R_3, and R_4, the function of which will now be described. Resistance R_1 is a variable resistance which functions to enable a manual setting of a desired setpoint temperature, and may be set by an operator to any predetermined desired temperature. Resistance R_2 (thermistor 70) is the temperature-variable resistor found in control module 62. Its resistance varies inversely with temperature,

the resistance decreasing as the sensed temperature increases, and increasing as the sensed temperature decreases. Resistance R_3 is a temperature variant resistor, which may also be a thermistor, whose resistance values vary inversely with temperature, and which is located in ambient temperature monitor 22. Resistance R_4 is a fixed value resistance whose function is to provide a resistor balance point for resistance R_3. In practice, resistances R_3 and R_4 are selected so as to be equal in value at a nominal ambient temperature, i.e. about 80°F (26°C), so that the leg of the resistance bridge comprising resistors R_3 and R_4 is balanced at a nominal ambient temperature. Resistances R_1 and R_2 form the other balanced leg of the resistance bridge circuit. Resistor R_2 (thermistor 70) varies inversely with the temperature of the hose simulator 60, and resistance R_1 may be manually set to a value corresponding to a desired temperature setting of the fluid within hose 16. Resistances R_2 and R_3, in the preferred embodiment, are products manufactured by Victory Engineering Corp., Springfield, New Jersey, under type designation VECO T45A35.

The voltage at the junction point 142 of resistances R_1 and R_2 is direct-coupled into bridge amplifier 150, which generates an output signal in response to this voltage. The voltage at the junction point 149 of resistances R_3 and R_4 is also direct-coupled into bridge amplifier 150 in the same respect. The output signal from bridge amplifier 150 appears on line 151, and is a voltage representative of a signal commanding more or less heat from the heating element 44, the higher the voltage level on line 151 the longer will be the duty cycle of the AC power driving the heating element, and therefore the more heat will be commanded.

This signal is fed into comparator and drive circuit 156 as one of two inputs received by that circuit. The second input into circuit 156 is a signal on line 157, which is a sawtooth voltage riding a DC voltage level. A 60 Hz output signal from circuit 156 will appear on line 145 at any time when the input signal on line 157 is at a lower voltage than the input signal on line 151. The signal on line 145 is used as a control signal input to triac circuit 144, effectively turning on triac circuit 144 to enable AC power to pass through the heating element and through resistor 58. FIG. 5 shows several voltage waveforms which may be found at the points indicated on the drawing.

A square wave generator 154 generates a repetitive signal having a period of approximately 1 1/2 seconds. This square wave signal is passed through resistance/capacitance network comprising resistor 158 and capacitor 160. This network produces a sawtooth waveform appearing on line 162 as an input to summing amplifier 164. The sawtooth waveform on line 162 is referenced at a potential of 4 volts having equal portions ($\pm$ 1 1/2 volts) of voltage swing about that voltage. A differential amplifier 152 has an input coupled to junction point 142 via a capacitor 143. Differential amplifier 152 reacts to changes in voltage at junction point 142, and the output of differential amplifier 152 is a signal on line 153 which is a DC voltage representative of the rate of change of voltage at point 142. The signal on line 153 is summed with the signal on line 162 by summing amplifier 164, and the output of summing amplifier 164 is therefore a sawtoothed voltage riding a DC level as has been hereinbefore described. It should be noted that the signal received by summing amplifier 164 from line 153 is received at an inverting (-) input terminal, whereas

the signal received by summing amplifier 164 from line 162 is received at a noninverting (+) input terminal.

The components selected for the control circuit illustrated on FIG. 5 are all standard commercial components which are commonly available. For example, the power supply, comparator, and drive circuits 146 and 156 are in a single integrated circuit manufactured by RCA, under Type CA3058. The components making up bridge amplifier 150, differential amplifier 152, summing amplifier 164, and square wave generator 154 are all found in a single integrated circuit manufactured by National Semiconductor Company, as Type LM124. In the preferred embodiment resistor 158 has been selected to have a value of 150 kilohms (150 K), and capacitor 160 has been selected to have a value of 10 microfarads (uf). Similarly, capacitor 143 has a value of 11 uf, capacitor C_1 has a value of 50 uf, and resistor R_4 has a value of 47 K. Resistor R_1 is a variable potentiometer having a nominal range of values from 0 to 45 K.

In operation, resistor R_1 is nominally set by the operator to a setting representative of the desired hose liquid temperature. AC power is than applied to the circuit, and the circuit begins operating. Since the fluid temperature of hose simulator 60 is initially lower than the temperature setting of R_1, a relatively positive voltage will be present at point 142, which will be amplified by bridge amplifier 150 resulting in a positive voltage on line 151. Since the positive voltage on line 142 is initially unchanging, the output of differential amplifier 152 is initially zero, and the output of summing amplifier 164 is therefore a sawtooth waveform riding about a 4 volt level. To the extent the voltage on line 157 is lower than the voltage on line 151, circuit 156 will generate a 60Hz output signal on

line 145. The signal on line 145 will trigger triac circuit 144 to cause AC power to pass through heating element 44 and resistor 58. Initially, it may be presumed that the signal on line 157 is lower than the voltage on line 151 during almost the entire sawtooth period, resulting in a 60Hz continuous output signal from circuit 156, and therefore resulting in a triggering of triac circuit 144 and applying AC power to heating element 44 and resistor 58. This causes the temperature in control module 62 to increase and brings about a decrease in the resistance of R_2. Therefore, the voltage at point 142 begins dropping at a rate consistent with the rise in temperature. Bridge amplifier 150 develops an output signal on line 151 which follows the change of voltage at point 142, but capacitor C_1 shunts any rapidly changing voltage, effectively desensitizing bridge amplifier 150 during times when the rate of change of temperature is rapid. Conversely, the rate of change of voltage at point 142 is sensed by differential amplifier 152 to generate a negative voltage on its output line 153. The voltage on line 153 is summed with the sawtoothed waveform on line 162 to generate a less negative-riding sawtoothed voltage on line 157. As the temperature within control module 62 reaches the nominal setpoint temperature, the voltage at point 142 becomes more negative and the output from bridge amplifier 150 becomes more negative. This results in the signal on line 151 dropping in magnitude and thereby decreasing the drive signal from circuit 156. This decreased drive signal results in a lowered duty cycle operation of triac 144, and gradually lowers the amount of AC power fed into heating element 44 and resistor 58. As the amount of AC power diminishes the rate of change of increase of heat sensed by resistor R_2 diminishes and differential amplifier

152 generates a less negative output signal, tracking this rate of change. This causes the output signal on line 153 to decrease towards zero, and summing amplifier 164 produces an output on line 157 which is a sawtooth voltage riding a DC level approaching the 4 volt bias line. This effectively removes differential amplifier 152 from the circuit and causes summing amplifier 164 to pass a sawtooth voltage to comparator and triac drive circuit 156. At the nominal temperature setpoint the rate of change of voltage at point 142 becomes zero or near zero, differential amplifier 152 generates a zero or near zero output signal on line 153, and summing amplifier 164 generates a sawtoothed waveform on line 157 which is referenced about the bias voltage reference. This is compared with the signal on line 151, resulting in approximately a 50% duty cycle operation of triac switch 144.

When temperatures within the control module 62 are at or near the nominal setpoint temperature the voltage on line 151 tracks these minor disparities, increasing or decreasing slightly the duty cycle of triac switch 144 to increase or decrease AC power applied to the heating element 44 and resistor 58 by the small additional amount needed to compensate for the temperature disparity. Under these conditions bridge amplifier 150 functions as a high gain amplifier, and small voltage changes at junction 142 produce significant corrective voltages at line 151. When wide disparities exist between the temperature setpoint and the actual temperature the circuit permits rapid heat buildup by tracking the rate of change of actual temperature versus setpoint temperature, thereby permitting the circuit to develop full power until actual temperature approaches nominal temperature settings. The output from bridge amplifier 150 is

effectively desensitized by capacitor C_1, causing it to react with high sensitivity toward slowly varying temperature disparities, and with lower sensitivity towards rapidly varying temperature disparities. Conversely, the output from differential amplifier 152 causes it to react only toward rapidly varying temperature disparities, to control the triac switch 144 duty cycle when such temperature disparities exist.

All of the foregoing description presumes that a resistance balance exists between fixed resistor R_4 and ambient temperature sensing resistance R_3, which would be the case if the outdoor ambient temperature in the vicinity of ambient temperature monitor 22 is about 80°F (26°C). If the ambient temperature is higher than about 80°F (26°C), the voltage at junction 149 is relatively more positive, resulting in a more positive voltage being coupled to the second input terminal of bridge amplifier 150. Bridge amplifier 150 is a circuit which amplifies the difference signal sensed between its two input terminals, which means that when the ambient temperature is warmer than about 80°F (26°C) bridge amplifier 150 will generate a relatively lesser output signal on line 151 for a given temperature sensed by control module 62. Conversely, when the outdoor ambient temperature is lower than about 80°F (26°C), bridge amplifier 150 will generate a relatively higher output signal on line 151 for a given temperature sensed by control module 62. The net effect of all this is to cause temperature control circuit 18 to generate relatively more heating power on a cold day and relatively less heating power on a warm day.

The heat transfer characteristics of hose simulator 60 are selected so as to match as nearly as possible the heat transfer characteristics of a section of hose 16 having a length A. Under these conditions, even though

it is only the temperature of hose simulator 60 which is monitored and controlled, it may be presumed that the temperature of a section of hose 16 tracks the temperature of hose simulator 60 nearly identically.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof, and it is therefore desired that the present embodiment be considered in all respects as illustrative and not restrictive, reference being made to the appended claims rather than to the foregoing description to indicate the scope of the invention.

WHAT IS CLAIMED IS:

1. A system for electrically heating fluid hose for transporting one or more fluid components from a supply to a remote point of application, comprising
   a) a hose [16] having an electrically connectable heating element [44], sections of said hose having predetermined heat loss and heat absorption characteristics;
   b) a hose simulator [60] separated from said hose, said simulator having heat loss and heat absorption characteristics similar to said hose, and having therein electrically energizable means [58] for heating and means for sensing temperature [70];
   c) an electrical power drive circuit [156] connected to said hose heating element and to said hose simulator means for heating; and
   d) a control circuit [18] connected to said electrical power drive circuit, said control circuit having an input connected to said hose simulator means for sensing temperature.
2. The apparatus of claim 1, further comprising ambient temperature sensing means [22] for detecting ambient temperature and generating a signal output in response thereto; and means for coupling [149] said signal output to said control circuit input.
3. The apparatus of claim 1, wherein said hose simulator further comprises a resistance [58] enclosed in a volume container [59] and a temperature sensitive resistance [70] spaced from said resistance and enclosed in the same volume container;

4. The apparatus of claim 3, further comprising ambient temperature sensing means [22] for detecting ambient temperature and generating a signal output in response thereto; and means for coupling said signal output to said control circuit input.

5. The apparatus of claim 4, wherein said ambient temperature sensing means further comprises a temperature sensitive resistance.

6. The apparatus of claim 5, wherein said hose simulator temperature sensitive resistance and said ambient temperature sensitive resistance are respectively connected into a balanced bridge circuit [150] forming the input to said control circuit.

7. The apparatus of claim 6, wherein a further component of said balanced bridge circuit input is a manually adjustable resistance [R_1].

8. A system for monitoring and controlling the temperature of a heated fluid hose having predetermined heat transfer characteristics by electrical energization of a heating element in said hose in response to temperature monitoring of a hose section simulator, comprising

a) a control circuit [18] having power output drive terminals and having means for selectively varying the power at said output drive terminals in response to changes in input circuit resistance, and having one or more input terminals [143, 149] adapted for coupling to a resistance;

b) a hose section simulator [60] having a first resistor [58] encased in a volume [59], and having a second temperature responsive [70] resistor encased in said volume spaced away from said first resistor;

c) means for connecting said power output drive terminals to said hose heating element and to said first resistor; and

d) means for connecting said second resistor to one of said input terminals; whereby the heat transfer characteristics of said volume are simular to the heat transfer characteristics of said hose.

9. The apparatus of claim 8, wherein said volume is physically separate from said hose.

10. The apparatus of claim 9, further comprising a third temperature responsive resistance [R_3] coupled to another of said input terminals [149] .

11. The apparatus of claim 10, wherein each of said input terminals are respectively connected to and form a part of a resistance bridge circuit [150] in said control circuit.

12. The apparatus of claim 11, further comprising a manually adjustable resistance [R_1] coupled into said resistance bridge circuit.

13. The apparatus of claim 12, wherein said third temperature responsive resistance is positioned in exposure to atmospheric temperature.

14. A fluid delivery system for transporting heated fluids through a hose and for monitoring and controlling the fluid temperature in said hose, comprising

a) a length of fluid hose having an electric heating element [44] in close association therewith, said heating element extending along a predetermined length of said hose and having a connection to a pair of power drive terminals [140, 141];

b) a power drive circuit [156, 144] having output terminals connected to said power drive terminals, said power drive circuit having an input resistance bridge circuit [150] and having one or more input terminals coupled to said bridge circuit, said power drive circuit being capable of supplying variable power to said output terminals in response to resistance changes in said bridge circuit; and

c) a closed module [60] separate from said hose, said module having therein a first resistor [58] connected to said power drive circuit output terminals and a second temperature responsive resistance [70] connected to one of said power drive circuit input terminals.

15. The apparatus of claim 14, further comprising another temperature responsive resistance [R_3] exposed to the atmosphere and connected to another of said power drive circuit input terminals.

AMENDED CLAIMS
[received by the International Bureau on 13 March 1984 (13.03.84))
original claims 1 to 15 canclled; amended claims 1 to 5 are new]

1. A system for electrically heating fluid hose for transporting one or more fluid components from a supply to a remote point of application, comprising
   a) a hose [16] having an electrically connectable heating element [44], sections [A] of said hose having predetermined heat loss and heat absorption characteristics;
   b) a hose simulator [60] separated from said hose, said simulator having heat loss and heat absorption characteristics similar to said hose sections [A], and having therein electrically energizable means [58] for heating and resistance means [70] for sensing hose simulator temperature;
   c) an electrical power drive circuit [144, 156] connected in parallel to said hose heating element and to said hose simulator means for heating;

d) an ambient temperature sensing means [22] for detecting ambient temperature comprising a resistor [R3] whose resistance changes with ambient temperature; and

e) a control circuit [18] connected to said electrical power drive circuit, said control circuit having a balanced resistance bridge amplifier [150] and a resistance bridge having one leg comprising an adjustable set point resistor [R1] and said resistance means [70] for sensing hose simulator temperature, and further having a second leg comprising a fixed resistance [R4] and said resistor [R3] whose resistance changes with ambient temperature.

2. The apparatus of claim 1, wherein said hose simulator further comprises a resistance [58] enclosed in a volume container [59] and a temperature sensitive resistance [70] spaced from said resistance and enclosed in the same volume container.

3. A system for monitoring and controlling the temperature of a heated fluid hose having predetermined heat transfer characteristics by electrical energization of a heating element in said hose in response to temperature monitoring of a hose section simulator, and in response to temperature monitoring of ambient temperature, comprising

a) a control circuit [18] having power output drive terminals and having means for selectively varying the power at said output drive terminals in response to changes in input circuit resistance, and having one or more input terminals [142, 149] adapted for coupling to a resistance;

b) a hose section simulator [60] having a first resistor [58] encased in a volume [59], and having a second temperature responsive [70] resistor encased in said volume spaced away from said first resistor;

c) means for connecting said power output drive terminals to said hose heating element and to said first resistor;

d) a manually variable set point resistor [R1] connected to said second temperature responsive resistor [70], the junction point of said two resistors being connected to one of said input terminals [142]; and

e) a fourth resistor [R3] having a resistance which varies with ambient temperature, and a fifth resistor [R4] having a fixed resistance, said fourth and fifth resistors connected together and at their junction point connected to another of said input terminals [149].

4. The apparatus of claim 3, wherein said volume is physically separate from said hose.

5. The apparatus of claim 4, wherein each of said input terminals are respectively connected to a resistance bridge amplifier circuit [150] in said control circuit.

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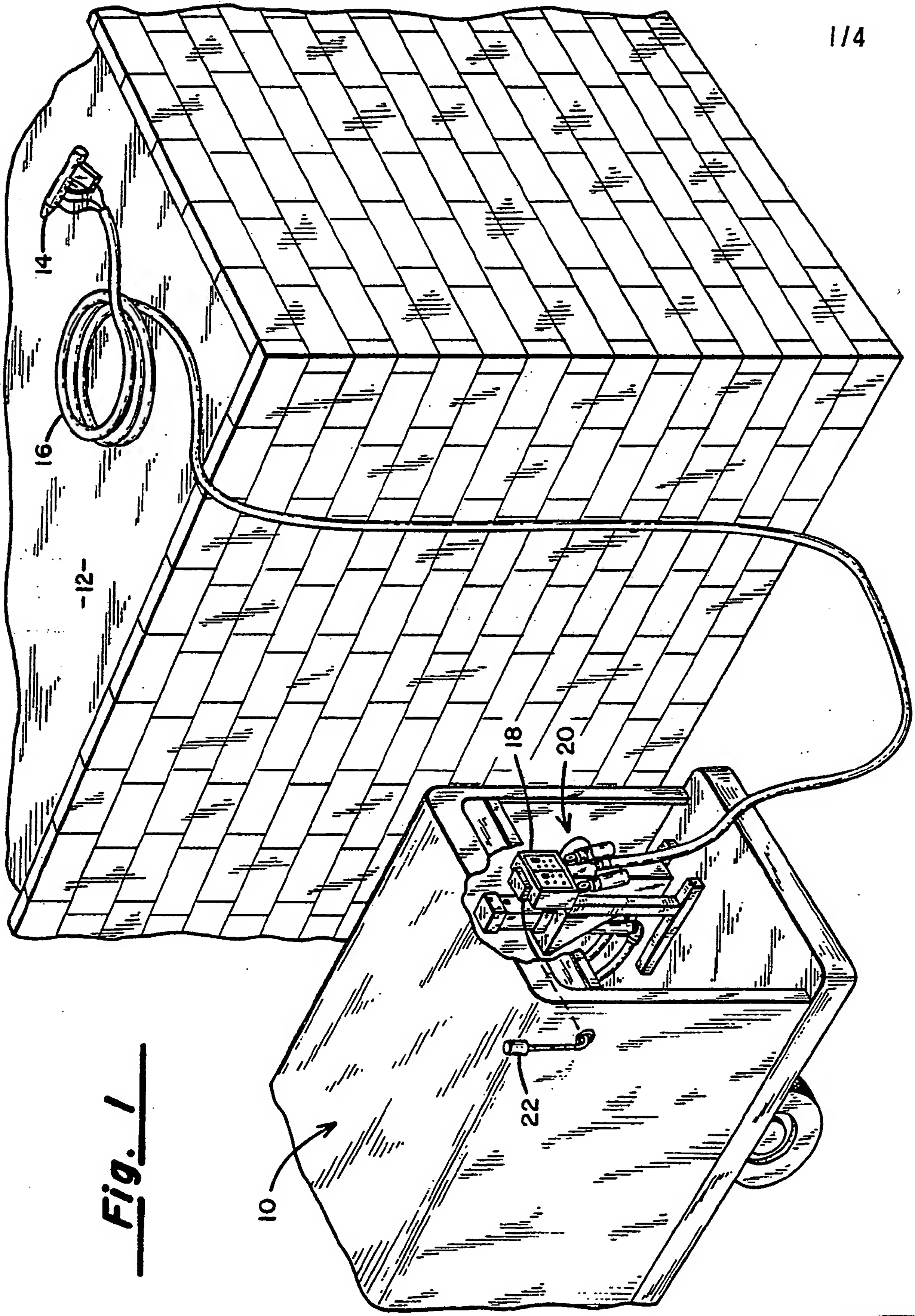

Fig. 1

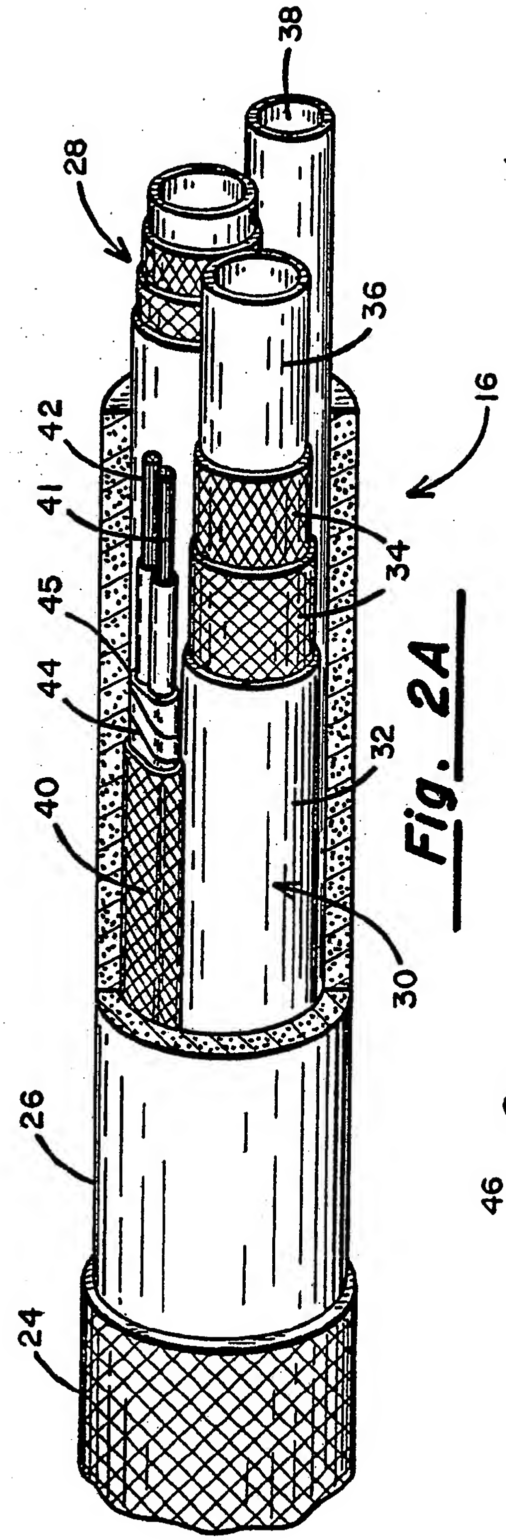

Fig. 2A

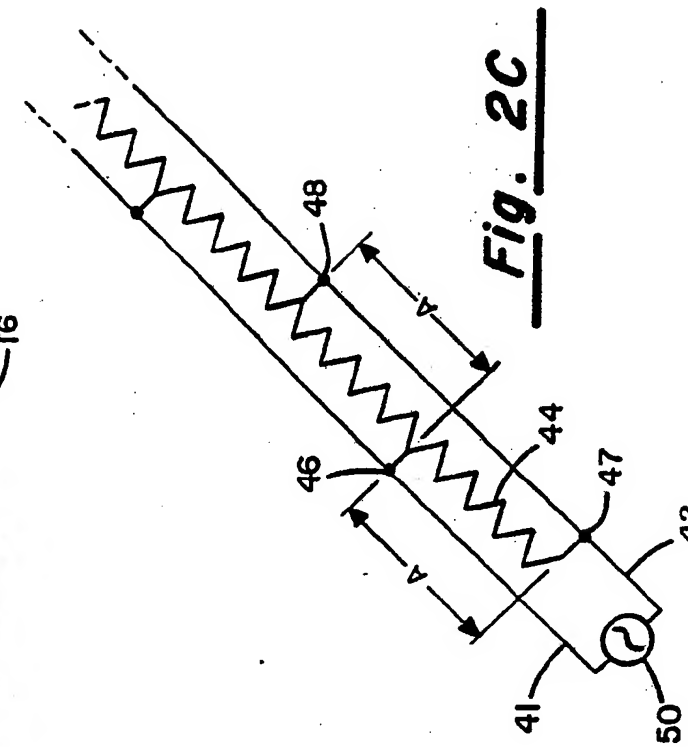

Fig. 2C

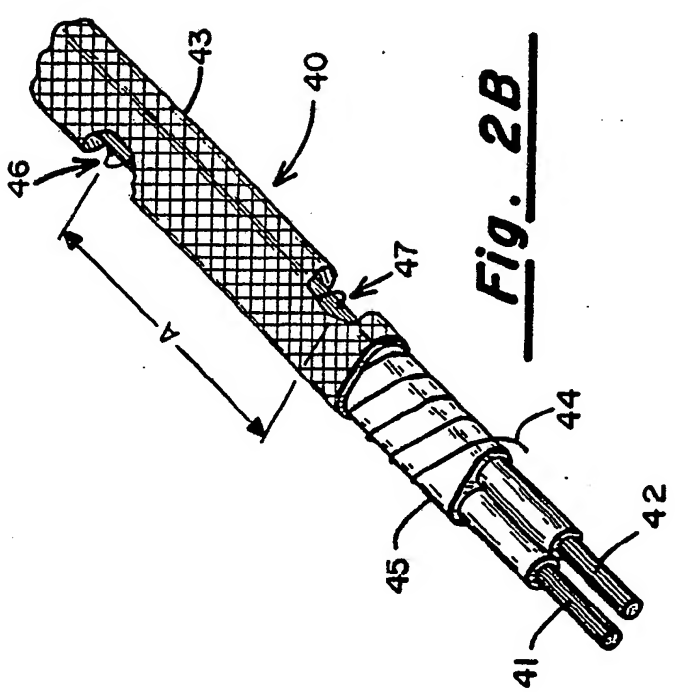

Fig. 2B

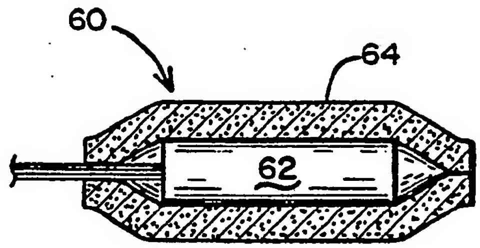

Fig. 3

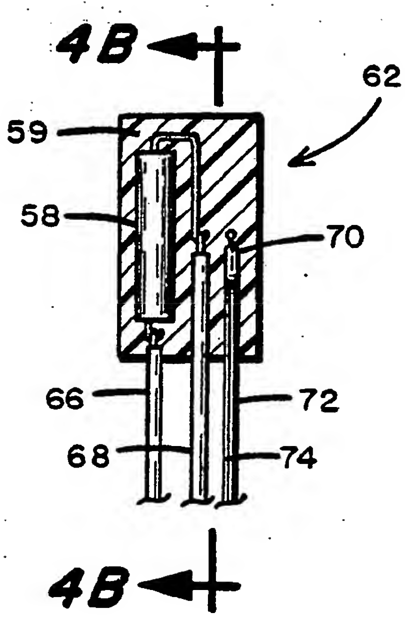

Fig. 4A

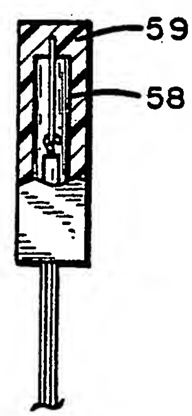

Fig. 4B

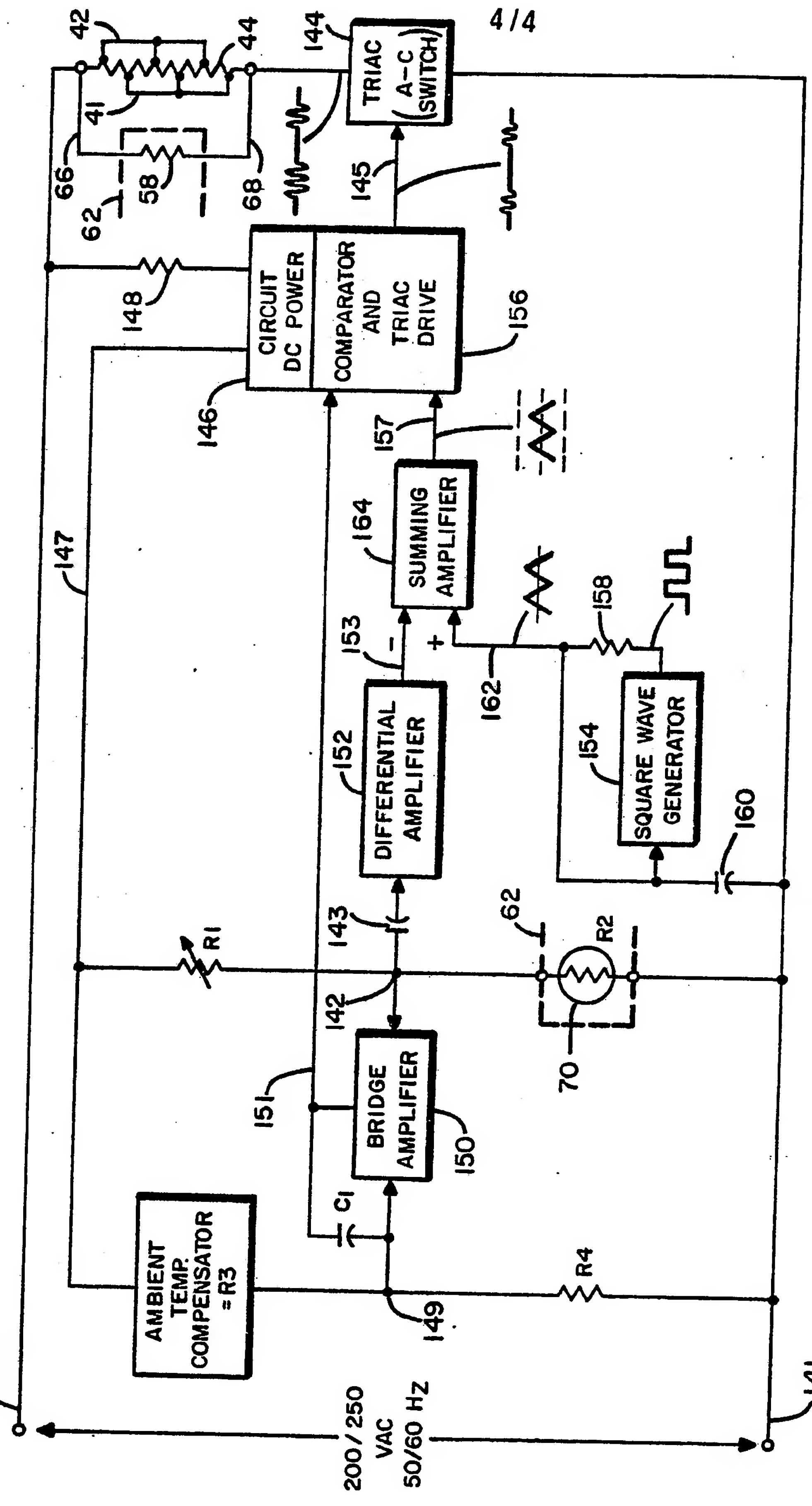
TRIAC (A-C SWITCH)
CIRCUIT DC POWER
COMPARATOR AND TRIAC DRIVE
SUMMING AMPLIFIER
DIFFERENTIAL AMPLIFIER
SQUARE WAVE GENERATOR
BRIDGE AMPLIFIER
AMBIENT TEMP. COMPENSATOR = R3
200/250 VAC 50/60 Hz
R1
R2
R4
C1
41
42
44
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Fig. 5

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 83/01633

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[3]

According to International Patent Classification (IPC) or to both National Classification and IPC

INT. CL^3 - H05B 1/02; B67D 5/62; B05B 1/24; G05D 23/30.
US CL - 219/301, 308, 328, 499, 505, 511; 222/146HE,

II. FIELDS SEARCHED

Minimum Documentation Searched[4]

Classification System	Classification Symbols
US	219/296, 300, 301, 306-308, 328, 494, 497-501, 505, 511; 222/146R, 146HE; 236/66R, 68B, 68C, 91R, 91G; 239/133, 135; 374/134.

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[14]

Category *	Citation of Document,[16] with indication, where appropriate, of the relevant passages[17]	Relevant to Claim No.[18]
Y	US,A, 3,803,385 (SANDORF) 09 April 1974	1-15
Y	US,A, 4,323,174 (WOOD) 06 April 1982	1-15
Y	US,A, 3,976,230 (SPERRY) 24 August 1976	1-15
Y	US,A, 4,031,355 (LEONIK) 21 June 1977	1-15
Y	US,A, 3,897,679 (GUILD) 05 August 1975, see col. 7, lines 16-36	1-15
Y	US,A, 2,593,459 (JOHNSON) 22 April 1952, see col. 4, lines 7-25	1-15
Y	US,A, 2,553,060 (MINER) 15 May 1951, see Fig. 2 and col. 2, line 44 to col. 3, line 66.	1-15

* Special categories of cited documents:[15]
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search[2]	Date of Mailing of this International Search Report[2]
10 January 1984	16 JAN 1984
International Searching Authority[1]	**Signature of Authorized Officer[20]**
ISA/US	A.BARTIS A Bartis

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No [18]
Y	US,A, 2,448,289 (ANDERSON) 31 August 1948, see Fig. 1 and col. 2, lines 3-35.	2,4-7,9-13 15
Y	US,A, 3,275,802 (VANDIVERE ET AL) 27 September 1966, see col. 1, lines 54-66.	2,4-7,9-13 15
Y	US,A, 2,522,826 (HOOVEN) 19 September 1950, see col. 2, lines 4-27.	2,4-7,9-13 15
A	US,A, 3,227,858 (REES) 04 January 1966, see Fig. 2.	3
Y	US,A, 3,062,941 (WHITE) 06 November 1962, see Fig. 1.	1-15
A	US,A, 1,522,122 (HEIDBRINK) 06 January 1925, see unit 32.	1-15
A	US,A, 3,096,424 (CECCHINI) 02 July 1963, see col. 2, lines 6-65.	1-15
A	US,A, 1,689,004 (ACKLEY) 23 October 1928, see page 1, lines 45-70.	1-15
A	US,A, 3,408,008 (COCKS) 29 October 1968	1-15
A	US,A, 1,781,244 (OSWALD) 11 November 1930, see page 3, lines 20-49.	1-15
A	US,A, 3,246,838 (BAUER) 19 April 1966, see col. 4, lines 19-42.	1-15
A	US,A, 3,364,337 (KAHN) 16 January 1968, see Fig. 3.	1-15
A	US,A, 2,518,277 (BREWER) 08 August 1950, see Fig. 2.	1-15

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

I 236/68B, 91G; 239/135; 374/134.

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers ...., because they relate to subject matter [12] not required to be searched by this Authority, namely:

2. ☐ Claim numbers ...., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:
3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:
4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.

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